



THE UNIVERSITY *of* EDINBURGH

Edinburgh Research Explorer

Marine Renewable Energy Seascape

Citation for published version:

Borthwick, A 2015, Marine Renewable Energy Seascape. in *The 2nd Global Grand Challenges Summit, Beijing, 15-16 September 2015*.

Link:

[Link to publication record in Edinburgh Research Explorer](#)

Document Version:

Publisher's PDF, also known as Version of record

Published In:

The 2nd Global Grand Challenges Summit, Beijing, 15-16 September 2015

General rights

Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.



The 2nd Global Grand Challenges Summit, Beijing, 15-16 September 2015

Alistair G.L. Borthwick, FEng, FRSE

**Institute of Energy Systems, School of Engineering, The King's Buildings,
The University of Edinburgh, Edinburgh EH9 3JL, U.K.**

Marine Renewable Energy Seascape

Abstract

Marine renewable energy has a major part to play in closing the world's energy gap and lowering carbon emissions. Key global challenges relate to technology, grid infrastructure, cost and investment, environmental impact, and marine governance.

Offshore wind turbines typically consist of three blades rotating about a hub. Although offshore wind technology is rapidly being implemented, there remain many fascinating engineering problems to overcome. These include: offshore foundations and floating support structures; alternative turbine designs based on 3D computational fluid dynamics; use of advanced materials for blades; ship manoeuvring for safe maintenance; and shared offshore platform applications (such as energy production, storage, and marine aquaculture).

Many innovative tidal stream energy devices have been proposed. An example is Salter's cross-flow turbine, which has blades arranged vertically, supported at each end on what are rather like enormous bicycle wheels. Although tidal power assessment seems easy, the very presence of tidal turbines alters the flow field, and in turn this affects power availability. Questions surround model uncertainty, turbulence, eddies, wave-current interaction, model scale-up, and environmental impact (e.g. on marine mammals and biodiversity). High performance and cloud computing should enable three-dimensional computational modelling to become routine in future. Scale model laboratory and pilot-scale field tests complement such analysis, providing validation data and insight into the *in situ* behaviour of tidal turbines.

Wave energy converter technology is another thriving area in which new inventions keep appearing. Here, engineers must find ways to maximise power output, improve efficiency, cut environmental impact, enhance material robustness and durability, reduce costs, and ensure survivability. Theoretical predictions of the power generated by wave energy converters require validation through laboratory-scale physical model studies and field tests. The latest simulation methods involve wave to wire modelling of arrays of wave energy converters, which integrates wave hydrodynamics, body responses, power take off, real-time control, and electricity production.

Ocean energy output is highly variable and so energy storage is essential. Compressed air energy storage, hydrogen storage, and substitute natural gas are particularly appealing options. At MaREI in Ireland, a marine power to gas concept is under development, where electrolysis is used to generate hydrogen, which is then converted to methane to be added to the natural gas network. Marine biomass is another source of marine renewable energy, through conversion to biofuel.

Novel materials with improved strength, fatigue, durability, and anti-corrosion properties are already on the horizon. Advanced composites, such as glass-fibre reinforced polymers, are ideal for cost reduction and increased reliability.

Access to ocean energy systems is expensive and hazardous. Present and future challenges include remote monitoring, control systems, robotics for operational support, and real-time weather forecasting for predictive maintenance to ensure devices can survive in extreme sea states as they arise.

In summary, marine renewable energy has huge potential, but demanding global challenges have to be met before the seascape will give up its precious energy resources. As in the industrial revolution, a new generation of engineers is required with the ingenuity, wisdom, and boldness to meet these inter-disciplinary challenges.

Alistair Borthwick: Short Biography

Alistair Borthwick has more than 35 years' engineering experience, and was a member of the design team of the Hutton Tension Leg Platform, which won the Queen's Award for Technological Achievement in 1984. He is Director of Mechanical Engineering and Professor of Applied Hydrodynamics at The University of Edinburgh, and an Emeritus Fellow at St Edmund Hall, Oxford. He is also Adjunct Professor of Environmental Engineering at Peking University, China, and Adjunct Professor of Marine Energy at NUI Galway, Ireland. Prof. Borthwick was previously a Professor of Engineering Science at the University of Oxford, where he worked for 21 years from 1990-2011. He was Head of Civil & Environmental Engineering at University College Cork from 2011-13, where he was the Founding Director of the SFI Centre for Marine Renewable Energy Ireland (MaREI). His research interests include environmental fluid mechanics, computational hydraulics, flood risk management, and marine renewable energy. Prof. Borthwick was awarded a DSc by the University of Oxford in 2007. He is a Fellow of the Royal Academy of Engineering and a Fellow of the Royal Society of Edinburgh.